



Test Results Document

Experiment results and findings

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Test Results Document – Emulation Project

I. Revision history

Revision number	Revision date	Author	Summary of changes
0.1	16-01-2006	J.R. van der Hoeven	Initial version
0.2	10-02-2006	J.R. van der Hoeven	Included DB tests
0.3	14-02-2006	J.R. van der Hoeven	Translated in English
0.4	23-02-2006	J.R. van der Hoeven	Added general evaluation and appendices
1.0	24-02-2006	J.R. van der Hoeven	Finalised
1.1	19-07-2006	J.R. van der Hoeven	Changed results base don changes in test description document

II. Related documents

Document name	Date	Author
Test Description Document	23-11-2005	J.R. van der Hoeven
Digital Preservation Testbed: Research Framework	27-04-2004	Testbed

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1 Introduction

During January and February 2006 different experiments with digital objects and emulation have been carried out as part of the emulation project. This project, which is a cooperation between the Koninklijke Bibliotheek (KB) and the Nationaal Archief of the Netherlands, primarily has the following goal:

“To develop a strategy for long-term preservation and access to digital objects based on emulation.”

To achieve this goal, an emulator has to be developed which is durable, without the need to migrate the emulator periodically or change the strategy itself.

1.1 Purpose of testing

To find out which requirements the emulator has to meet, it is important to take a closer look at the significant properties of different types of digital objects. Besides that, various existing emulation-solutions outside the field of digital preservation has to be examined. To do so, several experiments have been carried out.

1.2 Testprocedure

The testprocedure is divided in three steps:

1. Define the a list of properties of digital objects. This list will be used during the experiments.
2. Carry out experiments with different emulators and virtual machines and compare these results with the Reference Workstation (RWS) of the KB.
3. Evaluate the experiments done in step 2.

This document describes the results of steps 1 and 2 and evaluate them.

2 Results step 1

2.1 Significant properties

During step 1 the significant properties of different digital objects have been defined. These properties are based on the following scope of object types:

- PDF documents
- Interactive multimedia applications, published on CD-ROM
- Database systems (including dataset, DBMS and front-end interface)

The properties are divided by the following basic characteristics of a digital object:

1. Content : the text, images, etc. from the object
2. Structure : the cohesion between different parts of the object
3. Context : the meaning of the object.
4. Appearance : the way an object is presented to the user.
5. Behaviour : the interaction of the object with the user or system.

2.2 Test criteria

Each of the significant properties is used as criterion during the experiments. Using the five characteristics of each object, the following properties (criterion) have been defined:

1. Content
 - a. Text
 - b. Images
 - c. Animation
 - d. Sound
2. Structure
 - a. Internal structure of the object
 - b. Cohesion between object and environment
3. Context
 - a. Meaning of the object
4. Appearance
 - a. Text format
 - b. Colours, contrast, brightness
 - c. Screen resolution
 - d. Screen refreshment
 - e. Smoothness of animation
 - f. Smoothness of sound
 - g. Sound volume
 - h. Sound quality
5. Behaviour
 - a. Performance
 - b. User interactivity
 - c. Mouse behaviour
 - d. Keyboard behaviour
 - e. Software behaviour
 - f. Data extraction

Based on these properties several digital objects have been compared with the RWS and emulation / virtualisation.

3 Results step 2

3.1 Approach

During step 2 a careful selection of emulators and virtual machines have been subject of a series of experiments. These experiments have been carried out following the sequence defined in *Test Description Document*.

As shown below, six processes have been defined: three for virtualisation and three for emulation. During each process, several objects of the same type is tested using two emulators or virtual machines. Aside from that, a null-experiment with the RWS is carried out defining how the original representation should look like.

	Virtualisation			Emulation		
Process	PDF	CD-ROM	DB	PDF	CD-ROM	DB
Experiment	<i>For each:</i> PDF	<i>For each:</i> CD-ROM	<i>For each:</i> DB	<i>For each:</i> PDF	<i>For each:</i> CD-ROM	<i>For each:</i> DB
	<i>Using:</i> VMware	<i>Using:</i> VMware	<i>Using:</i> VMware	<i>Using:</i> VirtualPC QEMU Bochs	<i>Using:</i> VirtualPC QEMU Bochs	<i>Using:</i> VirtualPC QEMU Bochs
Processnumber	13	14	15	16	17	18

Table 3.1: Processes and experiments

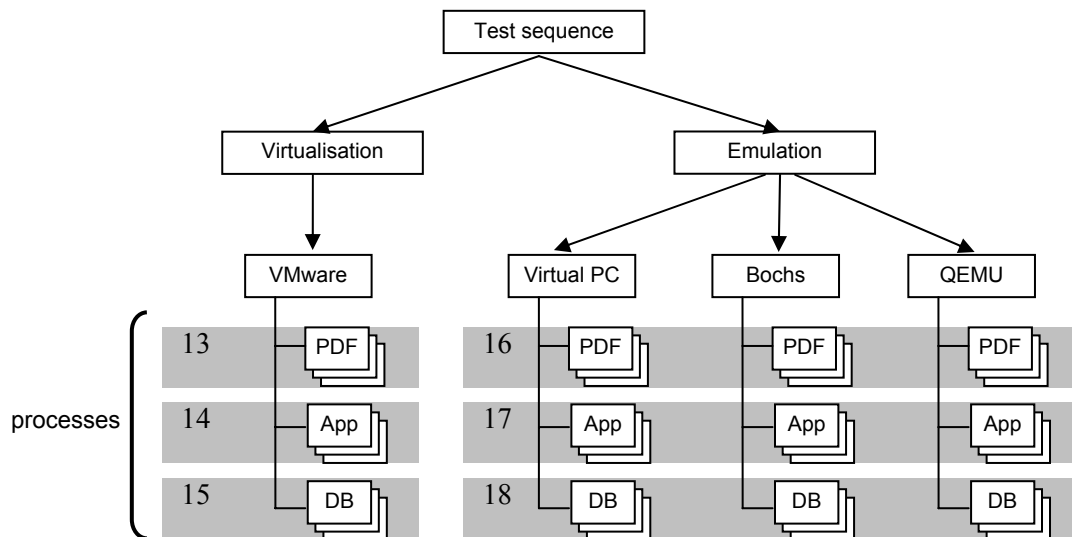


Figure 3.1: Schema of processes

The experiments have been carried out by three people:

Experiments 13, 14, 16, 17: Angelique Tempels (KB)

Experiments 15, 18: Liesbeth Keijser and Henny van Schie (Nationaal Archief)

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To compare the RWS with emulation and virtualisation as good as possible, processes 13 and 16 are carried out right after each other. The same is done for processes 14 with 17 and 15 with 18.

Each environment has its own shortname:

RWS = RWS
VW = VMware
VP = MS Virtual PC
QE = QEMU
BO = Bochs

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3.2 Configuration Reference Workstation (RWS)

The Reference Workstation (RWS) has the following system configuration:

Hardware	
System model	Compaq Evo D510 Convertible Minitower (CMT)
Processor	Intel Pentium 4, 2.4GHz
Motherboard	Compaq Evo D510 CMT
Memory	1 GB DDR
Storage	40 GB Maxtor 6E040L0, UATA 40 GB WDC WD400BB-60CJA0, UATA
Graphics	nVidia GeForce4 MX 420 display adapter
Sound	AC'97 SoundMAX Integrated Digital Audio
Removable storage	3.5 inch floppy drive DVD-ROM Drive (COMPAQ JLMS DVD-ROM LTD-1665)
Communication ports	2 COM ports, 1 LPT port, 4 USB ports
Network	100/1000 Ethernet network adapter
Monitor	CTX S500B
Keyboard	Compaq US keyboard for Microsoft Windows
Pointing device	Compaq PS/2 (Logitech) mouse, wheel, wired, mouse ball
Software	
Operating System	MS Windows 2000 Professional, SP2, 32 bit
Additional drivers	Display Drivers (Compaq nVidia LP AGP GeForce2MX-400) driver file: 41.03_win2kxp.exe (6.13.10.4103) SoundMAX sound device drivers driver file: SP22286.exe MS Direct X for NT, version 8 driver file: DX80NTeng.exe
Additional software	MS Internet Explorer 5.50.4134.0600 MS Windows Media Player 7.1 MS SysPrep 1.1 Power Quest Drive Image Pro 4.0 Java Plug-in for the browser 1.3.1_02 SE InterVideo WinDVD 2000 Paragon CD-ROM emulator 2.5 Personal Edition

Table 3.2: Configuration Reference Workstation (RWS)

For a more detailed list of specifications, see IBM's *RWS Microdesign* or the *Test Description Document*.

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3.3 Configuration test computer

The test computer, used for the experiments, has the following configuration:

Hardware	
Systemmodel	HP Workstation xw4200
Processor	Intel Pentium 4, 571 3.8 GHz, dual core
Motherboard	HP Workstation xw4200, model 0914h
Memory	2 GB DDR2
Storage	Harddisk 1: 400 GB, SATA Harddisk 2: 400 GB, SATA
Graphics	NVIDIA Quadro FX 1400
Sound	AC'97 SoundMAX integrated Digital Audio
Removable storage	3,5 inch Floppy drive CD-/DVD-ROM drive CD-/DVD-R/RW drive
Network	Broadcom NetXtreme Gigabit Ethernet (10/100/1000 Mbit)
Communication ports	1 COM port, 1 LPT port, 2 PS/2 ports, 5 pnp ports, 8 USB ports, 1 ethernet port, 1 SVGA port, 1 Digital video port, 1 TV-out port, 1 infrared port
Monitor	Philips Brilliance 170P, 17 inch
Keyboard	HP USB standard keyboard
Pointing device	HP PS/2 scrollwheel Mouse
Software	
Operating system	MS Windows XP, SP2, 32 bit (5.1.2600), standard image of Nationaal Archief
Additional drivers	Graphics driver for NVIDIA Quadro FX 1400 driver file: 81.67_forceware_winxp2k_english_whql.exe Sound driver for SoundMAX integrated digital audio driver file: sp27792.exe
Additional software	Adobe Acrobat 7.0 Professional Bochs 2.2.5 Broadcom 802.11 wireless LAN adapter Intervideo DVD check Intervideo WinDVD JDK SE 1.5.0.06 (v5 update 6), including Java webstart KB888111:High Definition Audio McAfee Virusscan Enterprise MS .NET framework 1.1 MS Office Professional 2003 MS Office Project Professional 2003 MS Office Visio Professional 2003 MS Virtual PC 2004 Mozilla Firefox 1.5 NVIDIA Drivers QEMU 0.8.0 (including QEMU manager) SoundMAX UltraISO v7.65 SR-2 VMware Workstation Windows Installer 3.1 WinImage WinRAR archiver ZENworks Desktop Management Agent

Table 3.3: Configuration of test computer

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3.4 PDF documents (processes 13 and 16)

In total three of the eleven PDF's (as described in the *Test Description Document*) from the test set have been tested. The reason for not testing all of the documents, is that the experiments were quite straight forward. The following PDF's have been tested:

1.0_20051027_gnostice2.02win_converted1.5ntvg1.pdf
1.3_20031223_dist4.05win_elsevier.pdf
1.5_20040928_dist4.0mac_ntvg_converted1.3_2.pdf

These PDF's vary from version 1.0 up to 1.5 from various publishers and created by different PDF generator tools on different platforms.

3.4.1 Configuration

The following configurations of the environment has been used for the experiments:

Environment	Host platform	Target platform
RWS	RWS + Adobe PDF Reader 5.01	-
VW	Testbed PC (WinXP) + VMware	MS Windows 2000 SP2, Adobe PDF Reader 5.01
VP	Testbed PC (WinXP) + Virtual PC	MS Windows 2000 SP2, Adobe PDF Reader 5.01
QE	Testbed PC (WinXP) + QEMU	MS Windows 2000 SP2, Adobe PDF Reader 5.01
BO	Testbed PC (WinXP) + Bochs	MS Windows 98 SE, Adobe PDF Reader 5.01

Table 3.4: configuration of platforms

Except Bochs, all other environments are running the same configuration. For Bochs MS Windows 98 SE was chosen, because Windows 2000 wasn't able to boot. However, the environment settings of both platforms were adjusted in a way that they were as close as possible.

3.4.2 Remarks

Fonts that are not embedded inside a PDF-document and that are not available on both the RWS and TestPC may be left unnoticed, as the font will probably be substituted by the same font on both environments. However, the substitution may result in a different appearance than the actual font looked like.

Data extraction has been tested by means of copying text and images from inside a PDF-document to another application within the virtual environment. Data extraction in the sense of *vernacular extraction* (terminology by Jeff Rothenberg: extracting data outside the emulated environment) is not tested, because this can not be compared with the RWS which is a standalone computer (no network or printer connection). Extraction of data in this case is thereby not considered.

3.4.3 Results

All PDF experiments were carried out by Angelique Tempels from the KB. For a complete list of results, see **appendix A**.

The overall impression of the experiments is that all environments were capable of reproducing the original publication on screen. However, there are some slight differences:

- The screen dimensions of the RWS differs from that of the TestPC. Measuring the exact dimensions showed that the aspect ratio (width:height) of the RWS is 1:1,34. That of the TestPC is 1:1,25.

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- The screen contrast of the RWS and the TestPC is different. This became visible when an reference inside a PDF-document was shown. On the RWS this reference was very clear blue, instead of the deep dark blue colour on the TestPC. This makes it more difficult to distinguish a reference from text.

Environment specific results:

Environment	Result
RWS	No problems reproducing the original PDF documents.
<i>Virtualisation</i>	
VW	Worked without any problem. All three test objects were reproduced correctly with correct behaviour.
<i>Emulation</i>	
VP	No major problems. Only first you have to enable the keyboard by pressing the CTRL-key.
QE	Initially, PDF-documents could not be tested, because there was no disk space available to install Adobe Acrobat Reader [ISSUE 1]. Short examination of the disk image learned that a lot of useless logfiles generated during OS installation consumed all available disk space. Freeing space by deleting the files, allowed the Adobe Acrobat Reader to install and perform the experiments. No problems occurred later.
BO	Bochs cannot run in full screen mode, which makes the environment not transparent for the user. Bochs is significantly slower than all others. The scrollwheel does not work.

Table 3.5: environment specific results for PDF documents

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3.5 Interactive multimedia applications (processes 14 and 17)

In total four of five interactive multimedia applications (as described in the *Test Description Document*) have been tested. One application, *Spellingscorrector*, could not be tested, because it required MS Word as additional application, which at that moment was not available on both RWS and emulated/virtualised environments. The following applications were tested:

Polycation-based gene delivery
Turnen in beweging
Topografie trainer
Deelsommen

These multimedia applications differ in user interactivity and system requirements, as specified in *Test Description Document*.

3.5.1 Configuration

On each distinct environment the same configuration has been used for each application.

Environment	Host platform	Target platform
RWS	RWS	-
VW	Testbed PC (WinXP) + VMware	MS Windows 2000 SP2
VP	Testbed PC (WinXP) + Virtual PC	MS Windows 2000 SP2
QE	Testbed PC (WinXP) + QEMU	MS Windows 2000 SP2 / MS Windows 98 SE
BO	Testbed PC (WinXP) + Bochs	MS Windows 98 SE

Table 3.6: configuration of platforms

During experiments, MS Windows 2000 did not work well on QEMU in all cases. In the case of testing *Topografie trainer* and *Deelsommen*, MS Windows 98 on QEMU was used instead. Bochs uses MS Windows 98 SE because it was not able to run MS Windows 2000 at all.

3.5.2 Results

Environment	Result
RWS	No problems reproducing the original applications.
<i>Virtualisation</i>	
VW	In general, worked correctly. Only at one time it appeared that the videobuffer was not refreshed correctly, resulting in differences between screen view and the actual computer state. The speed of VMware was amazing. Even more, when it was noticed that animation was running slightly faster than the same animation on the RWS.
<i>Emulation</i>	
VP	No major problems. Works a little bit slower than the RWS. Only you first must enable the keyboard by pressing the CTRL-key. Attaching a virtual CD-ROM to the target environment is less user-friendly, because it should be done right after starting up the target platform.
QE	Works significantly slower than the RWS. Screen sometimes freezes and in one particular case the text was completely scrambled. Animation was far too slow, although fluent. Mouse reacts faster than normal. Keyboard seems to hold the SHIFT-key. Sound was not available. In two cases the

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	multimedia application just crashed.
BO	Works extremely slow, which is not acceptable for interactive applications. Animation jumped over many frames, which makes it impossible to follow. It cannot run in full screen mode, which makes the environment not transparent for the user. The scrollwheel does not work. Sound is very jerky and difficult to follow.

Table 3.7: environment specific results for interactive multimedia applications

3.6 Database systems (processes 15 and 18)

Two database systems have been tested, one relying on MS Access with enclosed front-end and the other running as a stand-alone application with separate front-end and DBMS. The databases used for the experiments are:

Restrap database system
Retrieve database system

See *Test Description Document* for a description of both databases.

3.6.1 Configuration

Two different configurations have been used for the experiments with database systems.

Restrap database system

Environment	Host platform	Target platform
RWS	RWS (not suitable due to missing SP3)	-
VW	Testbed PC (WinXP) + VMware	MS Windows 2000 SP3 + MS Office 2003
VP	Testbed PC (WinXP) + Virtual PC	MS Windows 2000 SP3 + MS Office 2003
QE	Testbed PC (WinXP) + QEMU	MS Windows 98 SE + MS Office 97
BO	Testbed PC (WinXP) + Bochs	MS Windows 98 SE + MS Office 97

Table 3.8: configuration of platforms for restrap database

The Restrap database was originally formatted in MS Access 97, but was recently migrated to MS Access 2003 format. Therefore it is desirable to compare the migrated version under a virtual environment with the same environment in reality. However, to install MS Office 2003 under MS Windows 2000, Service Pack 3 (SP3) is required [ISSUE 3]. It was possible to configure this environment on VMware and Virtual PC, but not on the RWS, QEMU and Bochs (see also [ISSUE 4] and [ISSUE 5]). Therefore, a best effort solution was chosen for QEMU and Bochs by exporting the Restrap DB in Access 97 format again and running that under MS Windows 98 SE and MS Office 97 (see also [ISSUE 2]). The RWS could not be tested, because it only run Windows 2000 SP2 and MS Office 97 refused to install (also [ISSUE 2]).

Retrieve database system

Environment	Host platform	Target platform
RWS	RWS (not suitable)	-
VW	Testbed PC (WinXP) + VMware	MS Windows 98 SE + MS Office 97 + Borland DB
VP	Testbed PC (WinXP) + Virtual PC	MS Windows 98 SE + MS Office 97 + Borland DB
QE	Testbed PC (WinXP) + QEMU	MS Windows 98 SE + MS Office 97 + Borland DB
BO	Testbed PC (WinXP) + Bochs	MS Windows 98 SE + MS Office 97 + Borland DB

Table 3.9: configuration of platforms for retrieve database

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The Retrieve database requires MS Windows 98 and does not install on a MS Windows 2000 environment. Therefore, the database could not be tested on the RWS. Currently, the database is kept accessible by running Retrieve under VMware with MS Windows 98 SE installed. A similar approach was taken during the experiments under emulation and virtualisation. Aside from that, a Borland DB Engine is required which comes with the original Retrieve installation CD-ROM.

3.6.2 Results

General issues that occurred to all experiments are:

- Restrap database was read-only due to the fact that it was made accessible via a virtual CD-ROM. Copying the database to the virtual hard disk and adjusting the file properties by unchecking the read-only box solved the problem.
- Both Restrap and Retrieve could not use the printer, because no printer was configured. However, printing support would be very desirable.
- Image files from Retrieve are separated over two CD-ROMs. This makes it very user-unfriendly to browse through the set of records and showing the appropriate image.

Environment	Result
RWS	Not possible test on the RWS.
<i>Virtualisation</i>	
VW	In general, worked correctly. Sometimes unclear if you are working inside the VMware window or in the host environment, but this can be solved by explicitly activating the VMware window. Starting the Restrap database in MS Access prompted for a newer version of the MS Jet Engine. However, no problems occurred during runtime. The Retrieve database installed and run without problems.
<i>Emulation</i>	
VP	Worked correctly, although a lot slower than VW. You first must enable the keyboard by pressing the CTRL-key. Starting the Restrap database in MS Access prompted for a newer version of the MS Jet Engine. However, no problems occurred during runtime. The Retrieve database installed and run without problems.
QE	Worked slower than VW, but faster than VP. Starting the Restrap database caused a popup-message saying that this database has been downgraded from Access 2003 and that you may need to reconfigure the database modules. However, no problems occurred. The Retrieve database installed and run without problems.
BO	Worked extremely slow, which is not acceptable for querying a database. The scrollwheel didn't work. The Bochs window could not be viewed full-screen. Starting the Restrap database caused a popup-message saying that this database has been downgraded from Access 2003 and that you may need to reconfigure the database modules. However, no problems occurred. Copying the Restrap database from virtual CD-ROM to virtual hard disk failed. The Retrieve database installed and run without problems.

Table 3.10: environment specific results for database systems

4 Issues encountered

Issue 1: QEMU virtual hard disk full problem

Problem: after installation of MS Windows 2000 on the QEMU virtual hard disk of 4 GB, the hard disk was full.

Solution: during installation of the OS numerous log-files were created and stored in the directory `c:\winnt\security`. The purpose of these log-files was unclear, but they were probably created due to some installation problems of MS Windows 2000 (not clear what sort of problems). Deleting the files created 1.5 GB extra space and didn't result in any runtime problem.

Issue 2: MS Office 97 install problems

Problem: MS Office 97 will not install on MS Windows 98 / 2000, because the installation CD-ROM is recognized as upgrade and not a full version.

Solution: The installation CD-ROM is a full version of the application, but is recognized as upgrade. This restriction can be overruled by first installing MS Office 95. However, when MS Office 97 is installed, it first removes MS Office 95 completely before installing version 97. Installation works fine on both MS Windows 98 and 2000.

Issue 3: MS Office 2003 install problems

Problem: MS Office 2003 will not install on MS Windows 2000 SP2 (as on the RWS and test environments).

Solution: Service Pack 3 (SP3) is required for installation of MS Office 2003 on MS Windows 2000. Downloading and installing this additional package allows MS Office 2003 to install on MS Windows 2000.

Issue 4: Logon failure under MS Windows 2000 SP3

Problem: After installation of SP3 under MS Windows 2000 running on QEMU, restarting the target OS results in a logon failure. The file `msgina.dll` seems to be corrupt.

Solution: A copy of the file `c:\winnt\system32\msgina.dll` from the RWS was used which replaced the original `msgina.dll` file on the target OS. Replacement was done by starting another virtual hard disk under QEMU with the corrupted hard disk attached as second (extended) hard drive (else, the `msgina.dll` can not be replaced because it is in use).

Issue 5: MS Office 2003 install problems on QEMU

Problem: Although MS Office 2003 installed without any problem on MS Windows 2000 SP3 with VMware and MS Virtual PC, install problems still occurred under QEMU and MS Windows 2000 SP3. In error-log of MS Office 2003 the file `riched20.dll` seems to created an access violation. Probably the SP3 did not install successfully. A second try did result in the same problem.

Solution: No solution was found.

5 Evaluation

In general, the experiments that were conducted with virtualisation and emulation have shown that digital objects can be accessed within their authentic environment without using the original hardware on which they were created or used to render.

During the experiments, several differences and disabilities have appeared, varying from differences in screen contrast to software that could not be installed. Also severe problems occurred with performance and graphics display during some of the experiments.

5.1 Evaluation of tools

The following table shows statistic information about the number of times a virtualized or emulated environment was rated good (+), moderate (+/-) or bad (-).

Environment	# good (+)	# moderate (+/-)	# bad (-)
<i>PDF documents</i>			
RWS	45	0	0
VW	45	0	0
VP	42	3	0
QE	42	3	0
BO	38	4	3
<i>Multimedia apps.</i>			
RWS	72	0	0
VW	70	1	1
VP	67	5	0
QE	38	16	18
BO	35	23	14
<i>Database systems</i>			
RWS	n/a	n/a	n/a
VW	24	3	2
VP	23	4	2
QE	25	1	3
BO	20	3	6

Table 5.1: Number of rates for each environment

Although the test environments were not equal in all cases (due to incapability of the virtualisation/emulation software), several conclusions can be drawn about the tools used.

5.1.1 *VMware*

The virtualisation software from VMware is rated as the best tool by far. It showed to be fast and reliable for every object tested. Only a few minor details were encountered such as a refreshing problem of the videobuffer and misinterpretation of user interactivity when switching between the VMware target-window and host environment. Sometimes it was not clear if the window was active or not. However, the overall impression is very good.

5.1.2 *MS Virtual PC*

MS Virtual PC worked significantly slower than VMware, especially with CPU intensive operations. However, usability and reliability is as good as VMware. Like VMware, users of Virtual PC could be confused with switching between the host and target environment.

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Although a bit slower, Virtual PC is real emulation and makes it less tight to the underlying hardware.

5.1.3 *QEMU*

Although the MS Windows 2000 disk image created with QEMU initially caused a “disk full”-problem for some unknown reason, the emulator worked quite well for PDF documents and database systems. However, most problems occurred during experiments with multimedia applications, as sound did not work and animation was far too slow. In one particular case the text was shown scrambled on screen, whereas other virtualisation/emulation tools did not seem to have this problem. A positive aspect is that QEMU showed to perform much better on speed during database queries than MS Virtual PC. However, the opposite effect was shown during tests with multimedia applications.

5.1.4 *Bochs*

The Bochs emulator performed the least of all tools tested. Major disadvantages are its lack of speed, no full screen support, jerky sound, no working copy-function and no scroll wheel. Aside from that, it was not possible to install MS Windows 2000 running Bochs as emulated hardware. This resulted in an alternative target environment consisting of MS Windows 98 SE.

5.2 Conclusions

Evaluation of the results of the experiments with virtualisation and emulation tools showed great differences in capabilities and performance, resulting in different representations of digital objects.

When PDF documents should be kept accessible via virtualisation or emulation, each of the tested tools will be capable of doing so. If speed of execution and window/full screen mode are not any problem, both emulators and both virtualisation software will be sufficient.

However, interactive multimedia publications and database systems are much more demanding than PDF documents. To keep these kind of objects accessible in their authentic environment, high performance is required from processor, graphics, sound and user interactivity. Especially multimedia applications were operated very well by VMware and MS Virtual PC. QEMU and Bochs were disappointing, especially while running animation and sound.

Database systems were best viewed and queried within VMware and QEMU environments. MS Virtual PC strangely ran very slow during several query operations and Bochs was far too slow.

Although VMware seems to be the great winner of the experiments, it should be taken into account that VMware is built on virtualisation technology which is still very dependent on the underlying host platform. For emulation, MS Virtual PC / QEMU seems to do the best job, but showed to be less reliable than Bochs.

Appendix A: Results of experiments with PDF documents

PDF publication 1 : 1.0_20051027_gnostice2.02win_converted1.5ntvg1.pdf

Criteria					
<i>Process</i>	0	13	16		
<i>Content</i>	RWS	VW	VP	QE	BO
Text understandable	+	+	+	+	+
Images understandable	+	+	+	+	+
Animation understandable	n/a	n/a	n/a	n/a	n/a
Sound understandable	n/a	n/a	n/a	n/a	n/a
<i>Structure</i>	RWS	VW	VP	QE	BO
Internal structure of the object	+	+	+	+	+
Coherence object / environment	+	+	+	+	+/-
<i>Context</i>	RWS	VW	VP	QE	BO
Meaning understandable	+	+	+	+	+
<i>Appearance</i>	RWS	VW	VP	QE	BO
Fonts	+	+	+	+	+
Colour, constrast and brightness	+	+	+	+	+
Screen resolution	+	+	+	+	+/-
Screen refreshment	+	+	+	+	+/-
Animation fluent	n/a	n/a	n/a	n/a	n/a
Sound fluent	n/a	n/a	n/a	n/a	n/a
Sound volume	n/a	n/a	n/a	n/a	n/a
Sound quality	n/a	n/a	n/a	n/a	n/a
<i>Behaviour</i>	RWS	VW	VP	QE	BO
Performance	+	+	+	+/-	-
User interactivity	+	+	+/-	+	+
Mouse behaviour	+	+	+	+	+/-
Keyboard behaviour	+	+	+	+	+
Software behaviour	+	+	+	+	+
Data extraction	+	+	+	+	+

- + = okay / works correct
- +/- = moderate / works partly
- = bad / does not work
- n/a = not applicable to this object

Remarks:

VP: it looks like the CTRL-key is pressed constantly, but actually it is a toggle for switching between the target and host system. However, it works confusing.

QE: performance was a bit slower than virtualisation, but sufficient.

BO: Windows 2000 does not work. Instead, Windows 98 has been used. Full screen mode is not supported and screen refreshment is very low. Execution speed is significantly slower than the rest, but is sufficient. The scroll wheel is not recognised.

Test Results Document – Emulation Project

PDF publication 2 : 1.3_20031223_dist4.05win_elsevier.pdf

Criteria					
<i>Process</i>	0	13	16		
<i>Content</i>	RWS	VW	VP	QE	BO
Text understandable	+	+	+	+	+
Images understandable	+	+	+	+	+
Animation understandable	n/a	n/a	n/a	n/a	n/a
Sound understandable	n/a	n/a	n/a	n/a	n/a
<i>Structure</i>	RWS	VW	VP	QE	BO
Internal structure of the object	+	+	+	+	+
Coherence object / environment	+	+	+	+	+/-
<i>Context</i>	RWS	VW	VP	QE	BO
Meaning understandable	+	+	+	+	+
<i>Appearance</i>	RWS	VW	VP	QE	BO
Fonts	+	+	+	+	+
Colour, contrast and brightness	+	+	+	+	+
Screen resolution	+	+	+	+	+/-
Screen refreshment	+	+	+	+	+/-
Animation fluent	n/a	n/a	n/a	n/a	n/a
Sound fluent	n/a	n/a	n/a	n/a	n/a
Sound volume	n/a	n/a	n/a	n/a	n/a
Sound quality	n/a	n/a	n/a	n/a	n/a
<i>Behaviour</i>	RWS	VW	VP	QE	BO
Performance	+	+	+	+/-	-
User interactivity	+	+	+/-	+	+
Mouse behaviour	+	+	+	+	+/-
Keyboard behaviour	+	+	+	+	+
Software behaviour	+	+	+	+	+
Data extraction	+	+	+	+	+

- + = okay / works correct
- +/- = moderate / works partly
- = bad / does not work
- n/a = not applicable to this object

Remarks:

VP: it looks like the CTRL-key is pressed constantly, but actually it is a toggle for switching between the target and host system. However, it works confusing.

QE: performance was a bit slower than virtualisation, but sufficient.

BO: Windows 2000 does not work. Instead, Windows 98 has been used. Full screen mode is not supported and screen refreshment is very low. Execution speed is significantly slower than the rest, but is sufficient. The scroll wheel is not recognised.

Test Results Document – Emulation Project

PDF publication 3 : 1.5_20040928_dist4.0mac_ntvg_converted1.3_2.pdf

Criteria					
<i>Process</i>	0	13	16		
<i>Content</i>	RWS	VW	VP	QE	BO
Text understandable	+	+	+	+	+
Images understandable	+	+	+	+	+
Animation understandable	n/a	n/a	n/a	n/a	n/a
Sound understandable	n/a	n/a	n/a	n/a	n/a
<i>Structure</i>	RWS	VW	VP	QE	BO
Internal structure of the object	+	+	+	+	+
Coherence object / environment	+	+	+	+	+/-
<i>Context</i>	RWS	VW	VP	QE	BO
Meaning understandable	+	+	+	+	+
<i>Appearance</i>	RWS	VW	VP	QE	BO
Fonts	+	+	+	+	+
Colour, constrast and brightness	+	+	+	+	+
Screen resolution	+	+	+	+	+/-
Screen refreshment	+	+	+	+	+/-
Animation fluent	n/a	n/a	n/a	n/a	n/a
Sound fluent	n/a	n/a	n/a	n/a	n/a
Sound volume	n/a	n/a	n/a	n/a	n/a
Sound quality	n/a	n/a	n/a	n/a	n/a
<i>Behaviour</i>	RWS	VW	VP	QE	BO
Performance	+	+	+	+/-	-
User interactivity	+	+	+/-	+	+
Mouse behaviour	+	+	+	+	+/-
Keyboard behaviour	+	+	+	+	+
Software behaviour	+	+	+	+	+
Data extraction	+	+	+	+	+

- + = okay / works correct
- +/- = moderate / works partly
- = bad / does not work
- n/a = not applicable to this object

Remarks:

VP: it looks like the CTRL-key is pressed constantly, but actually it is a toggle for switching between the target and host system. However, it works confusing.

QE: performance was a bit slower than virtualisation, but sufficient.

BO: Windows 2000 does not work. Instead, Windows 98 has been used. Full screen mode is not supported and screen refreshment is very low. Execution speed is significantly slower than the rest, but is sufficient. The scroll wheel is not recognised.

Appendix B: Results of experiments with int. applications

CD-ROM publication 1 : Polycation-based gene delivery

Criteria					
Process	0	14	17		
Content	RWS	VW	VP	QE	BO
Text understandable	+	+	+	+	+
Images understandable	+	+	+	+	+
Animation understandable	+	+	+	+	+/-
Sound understandable	n/a	n/a	n/a	n/a	n/a
Structure	RWS	VW	VP	QE	BO
Internal structure of the object	+	+	+	+	+
Coherence object / environment	+	+	+	+	+/-
Context	RWS	VW	VP	QE	BO
Meaning understandable	+	+	+	+	+
Appearance	RWS	VW	VP	QE	BO
Fonts	+	+	+	+	+
Colour, contrast and brightness	+	+	+	+	+/-
Screen resolution	+	+	+	+	+/-
Screen refreshment	+	+	+	+	+/-
Animation fluent	+	+	+	+	-
Sound fluent	n/a	n/a	n/a	n/a	n/a
Sound volume	n/a	n/a	n/a	n/a	n/a
Sound quality	n/a	n/a	n/a	n/a	n/a
Behaviour	RWS	VW	VP	QE	BO
Performance	+	+	+	-	-
User interactivity	+	+	+	+/-	+
Mouse behaviour	+	+	+	+/-	+/-
Keyboard behaviour	+	+	+/-	+/-	+
Software behaviour	+	+	+	+	+
Data extraction	n/a	n/a	n/a	n/a	n/a

- + = okay / works correct
- +/- = moderate / works partly
- = bad / does not work
- n/a = not applicable to this object

Remarks:

VP: it looks like the CTRL-key is pressed constantly, but actually it is a toggle for switching between the target and host system. However, it works confusing. Attaching a virtual CD-ROM to the target environment should be done right after booting the target platform, which is less convenient.

QE: performance was a bit slower than virtualisation, but sufficient. Sometimes it was not clear if the emulator was busy or just stalled. Mouse is moving very fast and keyboard seems to hold the SHIFT-key.

BO: Windows 2000 does not work. Instead, Windows 98 has been used. Full screen mode is not supported and screen refreshment is very low. Execution speed is very slow making it impossible to understand the animations. The scroll wheel is not recognised. The colour red seems to be less clear.

Test Results Document – Emulation Project

CD-ROM publication 2 : Turnen in beweging

Criteria					
<i>Process</i>	0	14	17		
<i>Content</i>	RWS	VW	VP	QE	BO
Text understandable	+	+	+	-	+
Images understandable	+	+	+	+/-	+
Animation understandable	+	+	+	-	-
Sound understandable	n/a	n/a	n/a	n/a	n/a
<i>Structure</i>	RWS	VW	VP	QE	BO
Internal structure of the object	+	+	+	+	+
Coherence object / environment	+	+	+	+	+/-
<i>Context</i>	RWS	VW	VP	QE	BO
Meaning understandable	+	+	+	+/-	+/-
<i>Appearance</i>	RWS	VW	VP	QE	BO
Fonts	+	+	+	-	+
Colour, constrast and brightness	+	+	+	+	+
Screen resolution	+	+	+	+	+/-
Screen refreshment	+	+	+	-	-
Animation fluent	+	+	+	+/-	-
Sound fluent	n/a	n/a	n/a	n/a	n/a
Sound volume	n/a	n/a	n/a	n/a	n/a
Sound quality	n/a	n/a	n/a	n/a	n/a
<i>Behaviour</i>	RWS	VW	VP	QE	BO
Performance	+	+/-	+	-	+/-
User interactivity	+	+	+	-	+
Mouse behaviour	+	+	+	+/-	+/-
Keyboard behaviour	+	+	+/-	+/-	+
Software behaviour	+	+	+	+	+
Data extraction	n/a	n/a	n/a	n/a	n/a

- + = okay / works correct
- +/- = moderate / works partly
- = bad / does not work
- n/a = not applicable to this object

Remarks:

VW: the animations were running a little bit **faster** than the RWS.

VP: the animations were running a little bit **slower** than the RWS. The CTRL-key is pressed constantly, but actually it is a toggle for switching between the target and host system. However, it works confusing.

QE: Text was not readable and images partly. Animation was very slow and thereby not easy to follow. At start-up, the emulator seems to freeze for a while. Mouse is moving very fast. Keyboard seems to hold down the SHIFT-key.

BO: Animation was extremely slow and jerky, making it impossible to follow. Windows 2000 does not work. Instead, Windows 98 has been used. Full screen mode is not supported and screen refreshment is very low. Execution speed is significantly slower than the rest, but is sufficient. The scroll wheel is not recognised.

Test Results Document – Emulation Project

CD-ROM publication 3 : Topografie trainer

Criteria					
<i>Process</i>	0	14	17		
<i>Content</i>	RWS	VW	VP	QE	BO
Text understandable	+	+	+	+	+
Images understandable	+	+	+	+	+
Animation understandable	+	+	+	+/-	+/-
Sound understandable	+	+	+	-	-
<i>Structure</i>	RWS	VW	VP	QE	BO
Internal structure of the object	+	+	+	+	+
Coherence object / environment	+	+	+	-	+/-
<i>Context</i>	RWS	VW	VP	QE	BO
Meaning understandable	+	+	+	-	+/-
<i>Appearance</i>	RWS	VW	VP	QE	BO
Fonts	+	+	+	+	+
Colour, contrast and brightness	+	+	+	+	+
Screen resolution	+	+	+	+	+/-
Screen refreshment	+	+	+	+	-
Animation fluent	+	+	+	+/-	-
Sound fluent	+	+	+	-	-
Sound volume	+	+	+	-	+
Sound quality	+	+	+	-	+/-
<i>Behaviour</i>	RWS	VW	VP	QE	BO
Performance	+	+	+	+/-	-
User interactivity	+	+	+	+	+
Mouse behaviour	+	+	+	+/-	+/-
Keyboard behaviour	+	+	+/-	+	+
Software behaviour	+	+	+	-	+
Data extraction	n/a	n/a	n/a	n/a	n/a

- + = okay / works correct
 +/- = moderate / works partly
 - = bad / does not work
 n/a = not applicable to this object

Remarks:

VP: it looks like the CTRL-key is pressed constantly, but actually it is a toggle for switching between the target and host system. However, it works confusing.

QE: publication could not install on Windows 2000, but Windows 98 SE was possible.

However, during practice of a geography-course, the application crashed constantly, after clicking a irregular item on the screen. Speed was okay, although sometimes a bit slow.

Mouse is moving very fast and keyboard seems to hold the SHIFT-key.

BO: Animation was extremely slow and jerky, making it impossible to follow. Windows 2000 does not work. Instead, Windows 98 has been used. Full screen mode is not supported and screen refreshment is very low. Execution speed is significantly slower than the rest, but is sufficient. The scroll wheel is not recognised. Sound was not recognisable, because it was very jerky. Sound volume was good, but the was quality very low.

Test Results Document – Emulation Project

CD-ROM publication 4 : Deelsommen

Criteria					
<i>Process</i>	0	14	17		
<i>Content</i>	RWS	VW	VP	QE	BO
Text understandable	+	+	+	+	+
Images understandable	+	+	+	+	+
Animation understandable	+	+	+	+	+/-
Sound understandable	+	+	+	-	+/-
<i>Structure</i>	RWS	VW	VP	QE	BO
Internal structure of the object	+	+	+	+	+
Coherence object / environment	+	+	+/-	+/-	+/-
<i>Context</i>	RWS	VW	VP	QE	BO
Meaning understandable	+	+	+	+	+
<i>Appearance</i>	RWS	VW	VP	QE	BO
Fonts	+	+	+	+	+
Colour, contrast and brightness	+	+	+	+	+
Screen resolution	+	+	+	+	+/-
Screen refreshment	+	-	+	+	-
Animation fluent	+	+	+	+	-
Sound fluent	+	+	+	-	-
Sound volume	+	+	+	-	+
Sound quality	+	+	+	-	+/-
<i>Behaviour</i>	RWS	VW	VP	QE	BO
Performance	+	+	+	+/-	-
User interactivity	+	+	+	+/-	+
Mouse behaviour	+	+	+	+/-	+/-
Keyboard behaviour	+	+	+/-	+	+
Software behaviour	+	+	+	+	+
Data extraction	n/a	n/a	n/a	n/a	n/a

- + = okay / works correct
 +/- = moderate / works partly
 - = bad / does not work
 n/a = not applicable to this object

Remarks:

VW: creating a shortcut did not worked out well, because the screen was not refreshed properly, although it did not stall (probably the videobuffer was not updated).

VP: After installation of the publication, Virtual PC had to be restarting, which was not the case under VMware. The CTRL-key is pressed constantly, but actually it is a toggle for switching between the target and host system. However, it works confusingly.

QE: publication could not install on Windows 2000, but Windows 98 SE was possible. Speed was average and animation was okay. Sound did not work. Mouse is moving very fast and keyboard seems to hold the SHIFT-key.

BO: Animation was extremely slow and jerky, making it impossible to follow. Windows 2000 does not work. Instead, Windows 98 has been used. Full screen mode is not supported and screen refreshment is very low. Execution speed is significantly slower than the rest, but is sufficient. The scroll wheel is not recognised. Sound was very jerky, volume was good, but quality was low.

Appendix C: Results of experiments with Database systems

DB system 1 : Restrap

Criteria					
<i>Process</i>	0	14	17		
<i>Content</i>	RWS	VW	VP	QE	BO
Text understandable	n/a	+	+	+	+
Images understandable	n/a	+	+	+	+
Animation understandable	n/a	n/a	n/a	n/a	n/a
Sound understandable	n/a	n/a	n/a	n/a	n/a
<i>Structure</i>	RWS	VW	VP	QE	BO
Internal structure of the object	n/a	-	-	-	-
Coherence object / environment	n/a	-	-	-	-
<i>Context</i>	RWS	VW	VP	QE	BO
Meaning understandable	n/a	+	+	+	+
<i>Appearance</i>	RWS	VW	VP	QE	BO
Fonts	n/a	+	+	+	+
Colour, contrast and brightness	n/a	+	+	+	+
Screen resolution	n/a	+	+	+	+/-
Screen refreshment	n/a	+	+	+	+/-
Animation fluent	n/a	n/a	n/a	n/a	n/a
Sound fluent	n/a	n/a	n/a	n/a	n/a
Sound volume	n/a	n/a	n/a	n/a	n/a
Sound quality	n/a	n/a	n/a	n/a	n/a
<i>Behaviour</i>	RWS	VW	VP	QE	BO
Performance	n/a	+	+	+	-
User interactivity	n/a	+	+	+	+
Mouse behaviour	n/a	+	+	+	+
Keyboard behaviour	n/a	+	+	+	+
Software behaviour	n/a	+	+	+	+
Data extraction	n/a	n/a	n/a	n/a	n/a

- + = okay / works correct
- +/- = moderate / works partly
- = bad / does not work
- n/a = not applicable to this object

Remarks:

RWS: was not possible to run experiment on RWS, because SP3 is required.

VW: opening the database with Office 2003 resulted in a notification of an outdated MS Jet Engine. No printer configured. Querying the DB worked fast.

VP: opening the database with Office 2003 resulted in a notification of an outdated MS Jet Engine. No printer configured. Querying the DB worked fast.

QE: opening the database with Office 97 resulted in a notification of possible conversion errors due to the fact that the DB was converted from Access 2003 to Access 97. No printer configured. Querying the DB worked fast.

BO: opening the database with Office 97 resulted in a notification of possible conversion errors due to the fact that the DB was converted from Access 2003 to Access 97. No printer configured. Full Screen is not supported and refreshment is quite slow. Speed of execution is very slow. Querying the DB worked slow.

Test Results Document – Emulation Project

DB application 2 : Retrieve

Criteria					
<i>Process</i>	0	14	17		
<i>Content</i>	RWS	VW	VP	QE	BO
Text understandable	n/a	+	+	+	+
Images understandable	n/a	+	+	+	+
Animation understandable	n/a	n/a	n/a	n/a	n/a
Sound understandable	n/a	n/a	n/a	n/a	n/a
<i>Structure</i>	RWS	VW	VP	QE	BO
Internal structure of the object	n/a	+	+	+	+
Coherence object / environment	n/a	+/-	+/-	-	-
<i>Context</i>	RWS	VW	VP	QE	BO
Meaning understandable	n/a	+	+	+	+
<i>Appearance</i>	RWS	VW	VP	QE	BO
Fonts	n/a	+	+	+	+
Colour, contrast and brightness	n/a	+	+	+	+
Screen resolution	n/a	+	+	+/-	+/-
Screen refreshment	n/a	+	+	+	-
Animation fluent	n/a	n/a	n/a	n/a	n/a
Sound fluent	n/a	n/a	n/a	n/a	n/a
Sound volume	n/a	n/a	n/a	n/a	n/a
Sound quality	n/a	n/a	n/a	n/a	n/a
<i>Behaviour</i>	RWS	VW	VP	QE	BO
Performance	n/a	+	+/-	+	-
User interactivity	n/a	+	+	+	+
Mouse behaviour	n/a	+/-	+/-	+	+
Keyboard behaviour	n/a	+/-	+/-	+	+
Software behaviour	n/a	+	+	+	+
Data extraction	n/a	+	+	+	+

- + = okay / works correct
- +/- = moderate / works partly
- = bad / does not work
- n/a = not applicable to this object

Remarks:

RWS: was not possible to run experiment on RWS, because SP3 is required.

VW: Target window needs to be activated by mouseclick, which was confusing when you started typing directly. No printer configured. Querying the DB worked fast.

VP: Target window needs to be activated by CTRL-key, which was confusing when you started typing directly. No printer configured. Querying the DB worked slow.

QE: changing CD-ROM disks during emulation is not possible. No printer configured. Full screen did not work. Querying the DB worked fast.

BO: changing CD-ROM disks during emulation is not possible. No printer configured. Full Screen is not supported and refreshment is quite slow. Speed of execution is very slow. Querying the DB worked extremely slow.